OLOT, BARCELONA AND ÁVILA AND THE INTRODUCTION OF THE ARKWRIGHT TECHNOLOGY TO CATALONIA *

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RESUMEN

Este artículo muestra los medios a través de los cuales la industria algodonera catalana logró independizarse de las importaciones de hilo en una etapa crítica de su desarrollo entre 1790 y la Guerra de la Independencia. Ello fue posible gracias a la temprana difusión de la tecnología Arkwright, a lo cual contribuyeron hombres de negocios de Olot, Barcelona y Ávila vinculados a distintas ramas manufactureras. El artículo también muestra el carácter de la industria productora de maquinaria textil y los intentos realizados para limitar la difusión de la nueva tecnología.

ABSTRACT

This article clarifies the means whereby the Catalan cotton industry attained independence from imported yarn in a critical stage of its development between the 1790s and the War of Independence. It does so by tracking the origins, and early diffusion, of the Arkwright technology in Catalonia in the form of a machine-making and spinning company formed between an Olotí stocking frame knitter, a Barcelona silver-smith and an Ávila trained machine-maker. The spinning and weaving initiatives of the Company inform on the

N. de E.: Fecha de recepción del artículo: abril, 2002.
Fecha de aprobación por el Consejo de Redacción: mayo, 2003.

* The researching and writing of this article were made possible by a grant from The Economic and Social Research Council (award reference R000238515) and a visiting professorship during 2001 provided by the Institut d'Història of the Universitat Pompeu Fabra of Barcelona.

circumstances conditioning the Catalan industry's incorporation of the spinning processes. Light is also thrown on the character of machine-making at this stage of Catalan industrialization in a pilot-enterprise anxious to restrict technical diffusion.

JEL Classification: O31, N63, N930, N83, O14.

At the time Jordi Nadal wrote his chapter on «La industria algodonera catalana» in his celebrated *El fracaso de la Revolución Industrial en España* little was known about the early stages of the introduction of cotton machine spinning in Catalonia. Summarizing what was the generally accepted version of the events, Nadal affirmed that it was the ban imposed on the import of spun yarn on 20th September 1802 which was the catalyst for «la adopción de medios técnicos más modernos» – and that «hasta entonces, la única máquina utilizada había sido la "bergadana", movida a mano, versión ampliada de la "jenny" inglesa». The «medios técnicos», he states, were hydraulically powered Crompton mules. The evidence for their diffusion he drew from the Catalan records of concessions for use of water power. A first of these was made in 1803. It was followed by thirteen others between 1804 and 1807 [1].

Since Nadal wrote this account further research has increased the data at our disposition permitting a fuller description of the process though not one which differs in its essentials from the earlier version [2]. The range of spinning and associated machinery in use before 1802, it has been shown, was more extensive than Nadal's account might suggest — the unmodified version of the spinning jenny, introduced to Catalonia in late 1784, and which came to be referred to as the «máquina sencilla», had spread very widely, particularly from 1789-90, when harvest failure, and crises in the woollen and silk industries, drove many families in the Catalan interior into cotton spinning [3], the carding engine had been introduced in Barcelona in 1790, in the manufacture of the calico-printer Pablo Ramón [4], and been diffused both within and beyond Barcelona, where it was harnessed at an early stage to water-power (in Berga in 1792 [5] and in Ripoll in 1796) [6],

[1] Nadal (1975), p. 190. He provides the same version of events in his chapter «La indústria cotonera», in Nadal (1991), p. 21.

[2] Surveys of recent research are provided by Thomson (1992), pp. 234-267, and Sánchez (2000a), pp. 161-175.

[3] Sánchez (1988), p. 96 (2000), pp. 162-163; Thomson (1992), pp. 248-249, 255-258; Solà (1995), p. 12.

[4] Sánchez (2000a), p. 162.

[5] Thomson (1992), p. 255; Sánchez (2000a), p. 162; Solà (1995), p. 12.

[6] Cutrina Sorinas (1986), p. 42.

the Highs improved version of the jenny had been introduced in 1792, in Cardona, by an Englishman and from there had diffused rapidly and widely, its construction engaging fruitfully with an established machine making tradition in the area which had already achieved considerable improvements in the basic jenny [7], and examples of Arkwright's roller-spinning machines (referred to locally as «maquinas inglesas»), after an unsuccessful attempt at transfer to Barcelona in 1789 by two English machine-makers dispatched from Madrid by the Conde de Floridablanca [8], had been installed in Tarragona, following a cession of machinery by the Royal Cotton Manufacture of Ávila, by Severo Vila, a muslin-manufacturing, prebendary of the Cathedral [9], and constructed in Barcelona, for deployment in the Catalan border town of Olot, by Juan Serra, a Barcelona silver-smith, associated with an Olotí «negociant», Miquel Torroella [10], in the course of 1793. On the other hand the range of machinery did not in fact yet include the «bergadana» (Angels Solà has shown that this consisted in an improved Highs jenny, whose defining characteristic was its driving 120 spindles, developed around 1808) [11] — nor the spinning mule (known as «máquina francesa»). The latter, it has now been established, reached Catalonia via two channels between 1806 and 1807, from France, on the initiative of a French company, acting on behalf of the Conde de Cabarrús [12], and from the Royal Manufacture of Ávila, which sent examples of the machine, and appropriate pre-spinning equipment, built by its brilliant director, the engineer/machine-maker Agustín de Betancourt, to the two leading spinners at this point in the Principality: Jacinto Ramón of Barcelona and Dalmau, Martí, Codina and Serrano of Manresa [13]. These initiatives, combined with the prior introduction of steam-power by Jacinto Ramón in collaboration with the scientist Francisco Sanponts [14], make the years 1805-7 critical ones in the development of the sector.

With respect to technological diffusion recent research has more or less supported Nadal's position. Studies on the import of spun yarn from Malta and raw cotton from America show the latter growing very rapidly

[7] Thomson (1992), pp. 253-255; Solà (1995), p. 12; Sánchez (2000a), pp. 164-167.
[8] Thomson (1998), pp. 63-71.
[9] Martín García (1989), pp. 348-349.
[10] Sánchez (1996), p. 162 (2000a), pp. 170-172.
[11] Solà (2002), pp. 143-168.
[12] Grau & López (1974), p. 57, Zylberberg (1993), pp. 490-492; Sánchez (2000a), pp. 172-174.
[13] Martín García (1989), pp. 349-350; Sánchez (2000a), pp. 174-175.
[14] Agustí (1983), pp. 143-151.

from the end of the American war in 1783 but the former holding its position, reaching all time peaks in the years 1793 to 1796, confirming a continued, majority dependence of the industry on cotton imported already spun [15]. The outbreak then of war with England in 1797 interrupted the Maltese supply enforcing a more rapid take-up of machine spinning. This shift is held to have been given an additional impulse by what Alejandro Sánchez has termed a «vuelta al algodón» on the part of the Catalan investing class consequent on the further check which England's control of the sea had occasioned to what had been its most rapidly expanding trade, the export of printed linens to America, convincing it of the need to modernize the industry («concentrar la fuerza de trabajo y mecanizar el proceso productivo»). The 1802 ban on yarn imports thus remains a critical date but one which acted as a catalyst for changes already under way [16].

There are some problems, however, with respect to the manner in which the extent of the response to this catalyst has been assessed. The register of requests for concessions of water rights only records new requests and dependence on it, in consequence, leads to the ignoring of manufactures set up in sites use of whose water rights had already been authorized. Furthermore, of the sixteen recorded cases of rights being requested, only nine were specifically for cotton spinning — one (in Berga) was purely for carding and six others were for a range of possible purposes: paper-making, carding or spinning (two cases in Manresa); wool and cotton spinning, grinding of madder and «otras maniobras» (one case, Barcelona); for irrigation and for a manufacture to card and spin wool and cotton (Pobla de Lillet); for calico-printing or cotton spinning (Manresa) and for silk or cotton machinery (Manresa again). In addition in only three of the sixteen cases were they to provide water power to existing manufactures: the others were for planned manufactures («fábrica... que piensa construir» is how it is put in one case) for construction within between six months and two years. In most cases further evidence corroborates the foundation of these establishments. Existing rather than new hydraulic resources were being tapped at this stage and so the investments involved were not huge. There was however a speculative element in the rush of demands for such water rights [17]. The problems, it is clear, do not invalidate the source but

[15] Martín Corrales (1991), p. 130; Maixé Altés (1991), pp. 180-181.

[16] Sánchez (2000b), pp. 494-496.

[17] Archivo de la Corona de Aragón (henceforth ACA), Real Patrimonio, Intendencia, Registro 5/12, Llevador General de Concesiones 1763-1830.

they qualify its value for providing a precise record of the stages of the cotton industry's modernization.

A measure which does not suffer from this drawback, however, is that for the diffusion of the Arkwright machine. Its introduction in eleven additional enterprises to the two already referred to has been identified for the period 1793 to 1807. Three of these [the manufactures of Jacinto Ramón (1803), J. Guardia (1804) and Font Maynader (1805)] were in Barcelona and the Serra/Torroella concern had also been transferred to the Catalan capital at the beginning of 1795. The other eight were divided between Manresa [three concerns, Torras/Perera's (1804) and two belonging to the Codina/Dalmau company (1806)], Sabadell [one concern, that of Torroella (1804), a breakaway of 1799 from the Serra/Torroella company, first set up in Barcelona], Ripoll [the manufacture of Thomas Barrera (1805)], Sallent [Agustí Escayola's (1805)], Vic [Josep Font's (1806)) and Martorell (Joan Vilaregut's (c.1807)] [18]. Three foundations before 1802, ten between 1802-7: the data are clearly consistent with the view of a «take-off» in the rate of the cotton industry's mechanization following the 1802 ban.

Consequently particular attention is now given the diffusion of this technology. Sánchez notes that as well as increasing production it transformed the character of the emerging industry, its dependence on waterpower initiating changes in location which foreshadowed of «el mapa de la indústria catalana al segle XIX» and its high cost enforcing larger enterprises thus transforming spinning from an «indústria popular» to an «indústria de fàbrica». It is to the Arkwright machine, thus, he argues, that the «arrencada inicial» of Catalan industrialization should be credited, blazing the path for the mule-jenny which later was to become «la màquina per excellència de la primera industrialització catalana» [19].

To these grounds for attributing importance to the Arkwright machine should be added consideration of its technical characteristics: it combined the flexibility in terms of the range of yarns which it could produce which characterized all machine spinning with a particular suitability for the pro-

[18] Albareda Salvadó (1981), p. 51; Sánchez (1996), p. 162; Ferrer Alòs (1999), II, pp. 1047-1051. The figure of thirteen is a minimal one. Some of the concerns documented by Ferrer Alòs, for example, and which possessed Arkwright machines in 1845, were founded before 1807, almost certainly for the operation of Arkwright machines.

[19] Sánchez (2000a), pp. 170-172.

duction of stronger yarns in view of its capacity to put in more twist [20]. So much was this its distinguishing quality that in England it was known as the «twist frame» as often as «water frame» [21]. It thus could produce yarn strong enough to serve as warp. This was the reason for its playing a critical rôle in the British Industrial Revolution [22] and, it is evident, for its prominence in the Catalan experience. Without the Arkwright technology it is doubtful whether an adequate response to the opportunity for import substitution provided by the 1802 ban on yarn imports would have been possible.

Central though the Arkwright machine was to what was arguably the most impressive achievement of the Catalan cotton industry in the nineteenth century, the establishment of an import-substituting spinning sector without the aid of protective tariffs between the 1790s and 1820s [23], the details of its origins and the means by which it diffused are more obscure than those concerning any of the other key spinning inventions. Sánchez's recent survey article on Catalonia's first spinning machines reflects this. Speculating on the source of the technology in what was to be the principal Catalan agent in the introduction of the Arkwright machinery, the Serra/Torroella concern, he asserts that the machines *could* have been made by Pablo Serrano, a Madrid mechanic of known ability who probably had had experience of the Arkwright machines in Ávila or that otherwise it *might* have been he who built further machines which the Company later added to its original equipment. On the further question of the diffusion of the technology he is no more informative, limiting himself to stating that the Serra/Torroella concern was probably the only one functioning during the 1790s but that this status was soon going to change [24].

In this article an attempt will be made to fill a part of this critical gap in the story by recounting the experiences of the Serra/Torroella con-

[20] On the unsuitability of yarn from spinning jennies for warp thread see Hills (1970), pp. 60-61. On this facet of the introduction of the Arkwright technology see Thomson (1992), pp. 257, 262.

[21] Rees (1972), II, p. 176.

[22] Wadsworth & Mann (1931), pp. 492-493, shows though how alternative technologies were used for warp thread prior to the wide diffusion of the Arkwright frame.

[23] Domestic spinning fully replaced imported yarn and 34% share of the cotton cloth market was secured against English competition between 1792 and 1827 [Prados de la Escosura (1982), pp. 186 & 222: «el desarrollo de la industria algodonera no dependió exclusivamente del arancel, como pudiera deducirse del énfasis que en él ha puesto la historiografía»].

[24] Sánchez (2000a), p. 171. On the issue of diffusion he limits himself to the statement «Probablament aquest [the Serra/Torroella concern] fou un cas excepcional a la dècada dels noranta del segle XVIII, però també es cert que molt aviat ho deixaria de ser».

cern between 1793 and 1798 (the Tarragona case of transfer of Arkwright machines had no known repercussions). The enterprise grew rapidly to a substantial size. An inventory of its equipment carried out at the time of its division between its associates in 1799 shows that it possessed then 23 Arkwright spinning machines, 35 «simple» ones, 10 carding engines and 10 drawing, 10 roving and 7 bobbin frames. It had thus attained almost half the size of the spinning sections of the long-running, Ávila manufacture [25]. The growth in the manufacture *in itself*, it is clear, represented an important component in Catalonia's preparation for large scale reproduction of the Arkwright technology.

I am basing my study on two sources in particular. The first is this division document by means of which the company formed by Juan Serra and Manuel Torroella to operate the Arkwright machinery was split into two in 1799. Attached to it is a summary of the accounts of the Company for the five years of its existence as well as the inventory of its equipment and of its stocks. Between them these permit a reconstruction of the stages of the manufacture's development [26]. The second consists in the records of a court case beween Serra and Torroella which arose from disputes consequent upon this division [27]. It is a substantial source, running to over five hundred folios, for the case dragged on for seven years. It reveals many facets of the origins and development of this first Arkwright manufacture in Catalonia.

FOUNDATION OF THE ENTERPRISE

The contract by which Juan Serra, a Barcelona silver smith, and Miquel Torroella and company, Oloti stocking frame knitters and calico-printers [28], associated themselves is to be found at the front of the file containing the documents relating to their court case. Their company was formed on December 19th 1793 for a period of five years [29]. Its terms committed

[25] Sánchez (2000b), p. 496. If we use the count of spinning (Arkwright machines), carding, drawing and roving machines as a means of gauging size that for Ávila in 1796 was 114 against 53 for the Serra/Torroella concern in 1798 [Martín García (1989), p. 341].

[26] Arxiu Històrica de Protocols de Barcelona (henceforth AHPB), Manual of Joseph Ubach, 16 Aug. 1802, ff. 129-147.

[27] ACA, Audiencia, Real Consulado de Comercio, Pleito (henceforth Aud., RCC, Pl), 7450.

[28] Puig Reixach (1988b), p. 105.

[29] ACA, Aud., RCC, Pl. 7450, ff. 1-3.

the partners to making available to the company «todos los fondos» required as well as twenty five to thirty «maquinas sensillas con la mayor brevedad» in addition to putting at its disposition «una de nueva invención, otra de cardar, otra de menuar, y otra de hacer metcha, las qe estan ya concluidas». This machinery was to be set up «por ahora» in the town of Olot by the machine-maker Pablo Serrano who was also to construct three more «Maquinas de hilar de 48 usos de nueva invención», with «la posible brevedad» employing «los mancebos u mozos que sean necesarios».

Pablo Serrano *was* thus responsible for the construction of the first Arkwright machine in Catalonia. He had started on its construction on August 17th 1793 and it was his completion of a successful proto-type which had prompted the launching of the company. He completed the other three spinning machines to provide a full «set» of machines by March 24th 1794 [30]. Arkwright machines were diffused in sets which included all the equipment necessary for «continuous flow production» with a ratio of one carding engine, one drawing frame and one roving frame to four, 48 spindle, spinning machines [31]. It is not clear whether Serrano was responsible for all these other machines. Carding engines, as noted above, had been made in Barcelona since 1791 and it is possible that drawing and roving frames were known to machine-makers in the city, and their construction contracted out to them, too — only Serrano's spinning machine is described to as being of «nueva invención». This is though the first mention of such machines that has been found and it is thus probable that Serrano, who would certainly have had knowledge of them, would have at least supervised their construction if he had not actually carried it out himself. That he was building spinning machines with 48 spindles would support the argument that it was from Ávila that he had attained his skills for there, too, machines with this number were built [32].

In the contract it was further stipulated that Serrano would be granted leave of absence for two months on completion of the further three spinning

[30] Arxiu Historic de Protocols (AHPB), Antonio Ubach, 26 Aug. 1802, f. 136V. The entry reads «Por la construcción de 4 Maquinas Ynglesas p_a hilar Algodón q_e en la Llibreta de Letra A se expresa embiadas â Olot desde 19 Ag_{to} 1793 h_{ta} 24 Marzo de 94». I have interpreted the dates as referring to the process of construction of the machines rather than their transfer to Olot.

[31] Arkwright's combining a series of machines in a way to permit flow production was central to his invention and his originality in this respect has not been questioned [Tann (1973), pp. 41-42]. On the composition of the «sets», or «assortments» of machines for such flow production see Harris (1998), pp. 376-377 and Martín García (1989), p. 349.

[32] Martín García (1989), p. 343. The Arkwright machines whose transfer to Barcelona in 1789 was unsuccessful had 56 spindles each [Thomson (1998), p. 69].

machines in order to enable him to collect his wife from Madrid. On his return thence he was to instal «Diez maquinas de 48 ussos a fin de poder dar o sacar la utilidad q_e se espera de dicha fabrica» in the course of the year 1794 and to «trabajar y cuydar» that these machines, as well as the «maquinas sencillas», «todas vayan bien a fin q_e den la mayor utilidad». He was thus to act both as machine-maker and to have responsibility for the operation of his machines for the Company. He was required to work exclusively for the company's duration, making «todas las maquinas que sean menester, u las que pueda hacer en el espacio de cinco años» in return for a wage of 24 pesetas a week (just under 9 libras) and a fifth share of profits. The machines were to be the property of the Company.

The duties of the capitalist partners in the enterprise were also detailed. Juan Serra's were to consist in the buying of raw cotton (in Barcelona). Those of Manuel Torroella, son of Miquel [33], were to receive the cotton in Olot, direct the spinning processes and sell the yarn. Salaries of 300 libras were to be paid for these tasks. At the end of the five year period for which the company had been established the partners were entitled to leave the company but with the condition that they should provide six months' notice of their intention of doing so in order that the reimbursement of the leaving partner's investment should not result in the excessive depletion of the company's capital. These arrangements were to be «a la discreción de dhos socios, afin de hir con la mejor armonia».

The Company's terms, unusually for so formal a type of contract, communicate, as may have been noted, some of the excitement surrounding the technological breakthrough which had led to its foundation. The completion of such machinery was a major triumph. It was not the first example of such success, evidently, but even in Arkwright's case a major element of re-invention had been involved from the earlier Paul and Wyatt roller spinning machine. Indeed wherever Arkwright machinery was first constructed, the fact of its complexity, the need which there was for the construction of the spinning machines to be combined with that of further machinery for the pre-spinning processes, and the further difficulties generally encountered in making the machinery operable had the consequences that some-

[33] The partners in the enterprise were in fact Juan Serra and Miquel Torroella and Company of Olot. However Miquel Torroella had passed on his entire inheritance to his son, reserving though the usufruit, in 1788 making Manuel owner of the company and it was he who throughout was the active partner of Serra [Arxiu Històric Comarcal d'Olot (AHCO), Arxiu notarial d'Olot, Sayol, manual for 1788, ff. 74V-77R, act of 7 February 1788]. I am grateful to the assistance of Miquel Puig Reixach in locating this act and for other advice about Olot archives.

thing very similar to the «original» inventive process took place. The term «de nueva invención» is thus not a misnomer. The «invention» had been achieved rapidly by Serrano. It had taken Thomas Milne nearly a year and a half to complete a set of machines for Ávila despite the assistance of his brother Charles and his having brought with him machine parts and skilled workers from his father's manufacture in France [34]. François Martin, the first Frenchman who on his own account acquired the expertise necessary to establish an Arkwright mill (at Amiens) and to construct Arkwright machinery there had spent three years in England to qualify himself [35]. Excitement would have been added to by the fact that the city's lack of this key technology would have been well known about in view of the failed attempt to introduce it four years earlier alluded to and Ávila's success. That the latter was well known about in the city revealed by a statement of Antonio Bonaventura Gassó's, secretary of Catalonia's Junta de Comercio, made in 1792, mentioning the machinery «que con tan buen éxito ha establecido S.M. en Avila» and which Catalonia lacked in view of its high cost and the unavailability of models from which to copy it [36].

THE ASSOCIATES IN THE ENTERPRISE

What or who brought Pablo Serrano to Barcelona? How did such an apparently unusual combination in terms of skills, and geographical origins, as that between the Olotí merchant, stocking-maker and calico-printer Manuel Torroella, the Barcelona silver-smith Juan Serra and the probably Ávila-trained, Madrileño machine-maker come about? This too is clarified by the court-case. Serrano, it emerges, came to Barcelona of his own accord in search of backers. Once there «dió a entender que sabía la construcción de Máquinas Inglesas que entonces se ignoraban». Torroella it was who responded to this opportunity and mobilized the support of Serra to finance the carrying out of experiments in the construction of the machinery. Serrano, Serra was to attest, was unknown to him: it was Torroella who «le persuadió para que se le dexasen hacer pruebas». He made this point more than once declaring that it «Es constante que Serrano no era de

[34] Thomas Milne signed his machine-making agreement with his fellow-countryman John Berry in June 1788 and delivered his first assortment towards the end of 1789, Martín García (1989), pp. 222, 228-229, 289-290.

[35] Harris (1998), pp. 369-370.

[36] Cited by Sánchez (2000a), p. 170.

este Pais, y que vinó revestido de la habilidad q_e dixo tenia de formar Maquinas Inglesas. Lo es tambien que Torruella *[sic]* persuadió a Serra p_a q_e formase â cuenta de ellos alg_s maquinas al efecto de plantar fabrica de hilados. Estas verdades $facilm_{te}$ pueden entenderse considerandose que Torruella *[sic]* tenia fabrica de materias de algodón, y que Serra estando como estaba dedicado â su arte de Platero, lo que menos pensaba era en maquinas e hilados» [37]. A fuller understanding of the association requires the provision of what details can be gleaned about the background to each of the participants in it. This is what I shall now undertake.

1. Torroella

Accounting for Torroella's leading rôle in the introduction of the Arkwright technology is aided by referring to the extraordinary prosperity attained by his home town Olot during the eighteenth century. It came to be regarded as «el pueblo más laborioso e industrioso de Cataluña» [38]: trades practised within it including a large cloth industry, producing broadcloth which extended to the highest qualities as well as hats and stockings which were sold throughout Spain, the manufacture of smallwares, including silk lace, ribbons, sashes and printed handkerchieves, a large leather industry, tanning all types of skin, for sale largely in Barcelona, and producing also saddlery, for sale to the army, parchment and shoe soles, three shoe-manufactures, selling in Catalonia and Andalucia, an extensive and varied metal industry, composed of brass workers, tin-smiths, coopers, nail-makers, needlemakers, a file-maker, cutlers and a royal manufacture for cloth shears, clock- and playing card-makers, dyehouses and some 15 grain, and 6 paper mills driven situated along the river Flùvia whose course skirts the town [39].

This extensive industrial complex had been participating in that gradual process of enrichment which characterized Catalonia's 18th century [40], but, from the 1770's, Olot's merchants franchised a qualitative barrier in the

[37] ACA, RA, RCC, pl. 7450, ff. 172-185, 216-224. This is court evidence given in the context in this case of a desire on Serra's part to disinvolve himself for responsibility for what he is arguing was a costly commitment to Serrano. Torroella was in reply to claim at one point that «tubo Serra tanto conocimiento de d_{cho} Serrano que tuvimos nosotros» (f. 195). Torroella's earlier contact with Serrano is thus probable but not certain.

[38] Cited by Puig Reixach (Olot, 1988a), pp.

[39] Lluch (1981), pp. 21-25.

[40] Vilar (1987).

character of this growth by adopting the commercial practices of the capital: they founded a range of companies permitting them to pool their resources and engage in trades outside their own guilds, as the town came to play a leading rôle in the introduction of a range of new technologies from France. The purposes of the companies included the introduction, and then exploitation, of cotton stocking knitting frames, the operation of cloth friezing machines and the establishment of a manufacture for cloth-making cards. The stocking frames once introduced were imitated in Olot by its locksmiths some of whom became specialized knitting frame manufacturers. Once they had equipped the town's industry they supplied frames to a nascent, regional frame-knitting industry which was to have its main concentration along the Catalan littoral to Barcelona's north east. A notable feature of the industrial growth in the town which followed these initiatives was the development by «Garrotxi» (the «Garrotxa» was the «comarca» of which Olot was the capital) merchants and carters of their own distribution networks for their now mass produced products by means of a diaspora of agents established principally along Spain's Mediterranean coastline and within Andalucia [41].

The introduction and diffusion of the stocking frame were followed by other innovations — a diversification of the textile industry into calico-printing and then muslin— and calico-weaving, the early development of cotton spinning and, from the turn of the nineteenth century, the introduction of new dyeing techniques, in particular that of Turkey red [42]. It is the cotton spinning developments which are of particular interest to us. In their respect Olot was particularly quick to respond to the government-inspired policy of promoting the domestic spinning of American cottons. As early as 1775, just after a Barcelona Royal Spinning Company had been founded [43], the spinning of American cotton was undertaken on a considerable scale in the town to service the yarn requirements of some hundred stocking frames which were already in use. The development of this new sphere of activity does not appear to have been checked by the war with England between 1779 and 1783 (though there is evidence of some resort to cotton yarn smuggled in from France) for the Ayun-

[41] Puig Reixach (1988a), pp. 13-32, 37-38 & (1996), pp. 437-444; Lluch (1981), pp. 194-210, 219-233.

[42] Puig Reixach (1988b), pp. 105-120; Danés Torras, pp. 3956-3958.

[43] Thomson (1992), pp. 239-244.

tamiento was to claim in the latter year that American cotton was now being used for other cloths as well as stockings in view of its high quality [44].

This cotton was not used for muslins at this stage. The founders of this branch of the industry, the Masmitjá and Bastons company, in which the Bastons family was the principal investor, were, like other Catalan muslin weavers at this stage, purchasing high quality imported spun yarn in Barcelona . A large trade in the import of such yarn, largely from Switzerland, had built up [45]. Francisco de Zamora, the Castilian born jurist and administrator, employed in Barcelona's Audiencia, visiting Olot in 1787 commented on the «muy buenas muselinas» being produced on Bastons's sixteen looms and on two other «casas» taking up this trade [46]. Within a few years, however, yarn fine enough for muslins was being spun. The principal means by which this had been achieved was by increased skill in the construction, and operation, of the spinning jenny and Olot was at the forefront of this development. Its attainments are revealed in a lucid report, entitled «Sobre la importancia de la industria de telas de algodón, la posibilidad de extenderla y perfecionarla en España, y los medios de conseguirlo», written by Félix Torres Amat, canon of Tarragona cathedral, and secretary of the Sociedad de Amigos del País there, following a controversial, royal decision of September 7th 1789 to lift the ban on imported muslins, threatening thereby this emerging trade with extinction. In a section of the report which describes how «Las maquinas que dan muchos hilos â un tiempo, que al principio solo sirvieron para el hilo ordinario, ya le daban para muselínas medianas», the prominent rôle played by the Bastons enterprise in this change is recorded: «Luis Bastons y compania de Olot», Torres Amat wrote, «llegó a texer muselinas de numero 32 con hilados de maquinas de 30 a 60 husos. Y el ultimo año de la prohibición de las muselinas estrangeras, ya les salian los hilos algo mas baratos que los estrangeros». The entire production of 24 such machines was being devoted to muslin weaving.

Olot thus was achieving prominence in yet another industrial sphere, its experience proving virtually paradigmatic of that virtuous circle of economic growth, initiated by industrial protection, which, it was claimed by Jaume Amat, Félix's political economist/botiguer brother, was being achieved in Catalonia at this point. A central and desirable characteristic of this growth was held to be the diffusion of labour intensive manufacturing

[44] Puig Reixach (1988a), pp. 39-40.
[45] Miguel López (1999), p. 292.
[46] Puig Reixach (1988a), p. 22.

processes, such as spinning and weaving, to smaller towns and rural centres such as Olot: «Comprendo qe el medio mas seguro de fomentar la introducción de los hilados de algodones», Félix Torres Amat wrote, «[es de] facilitar q_e sus telares se repartan por lo interior de la Provincia» [47].

The Torroellas were one of many Oloti families which had been benefiting from their town's exceptional prosperity. Described as «negociants», «Pere and Miquel Torroella», father and son, had been involved in the rather conservative, commercial outlet of farming municipal taxes but during the 1780s they branched out, firstly into stocking frame knitting and then into calico printing [48]. Their grandson/son Manuel, the active agent in the establishment of the Serra/Torroella company, who appears to have been an only son, widened yet further the family's interests by means of his marriage to a daughter of Pere Molleras who was the leading stocking-frame manufacturer in the town. Molleras had attempted to market his machines to stocking manufacturers in Barcelona during the 1780s. Links between Manuel Torroella and the Molleras family became close. His father-in-law lent him 1720 libras «en negoci» in 1779 and he was to have extensive business dealings with his brother in law Joan Molleras [49].

What brought Manuel Torroella to Barcelona? Again references to general trends in the Garrotxa will contribute to clarifying this. As Olot had grown its links to the capital had intensified. A complex interaction was developing: the town's frontier rôle made it a relay in technological transfer to Barcelona and it, in turn, benefited from a diffusion of techniques from the capital: it was from thither that it had obtained its calico-printing and a Drawing School set up in 1783 to service this industry was an offshoot from Barcelona's Escuela de Nobles Artes [50]. In addition the town's growing cotton industry had a constant dependence on Barcelona as the regional source for raw and spun cotton and the distribution network which it had

[47] This report, and another which Torres Amat composed, «Observaciones sobre el Real Decreto de 7 de setiembre de 1789, que permite la entrada y uso de Muselinas estrangeras no pintadas», are the best source on this virtually unnoticed trade in spun yarn and muslin weaving which developed following a ban on muslin imports imposed on 24th June 1770. The manuscripts are contained in the Fons Torres Amat (Biblioteca de Catalunya, 3734). The page references to the Olot developments (they are contained among a selection of Torres Amat's writings) are 221-222. On Jaume Amat's political economy see Lluch (1973), pp. 167-179. The comment on increasing spinning is separate from the two reports, among general notes of Torres Amat's on cotton (p. 327 of the bound papers).

[48] Notes on Torroella family provided by Miquel Puig Reixach; Puig Reixach (1988), p. 105.

[49] AHCO, Arxiu Notarial d'Olot, Sayol, 1804, folio 1. Puig Reixach (1988b), p. 105.

[50] Sala Giralt (1974), pp. 10-17.

established for its products necessitated the collaboration of Barcelona financial intermediaries. In these circumstances there was regular toing and froing between Olot and Barcelona by the town's merchants as well as some migration to the capital on a permanent basis by members of leading, Oloti mercantile families. Luís Anglada, for example, son of Josef, who claimed to have introduced the stocking frame to Olot, went to Barcelona in the 1780s to learn the trade of stocking-maker no doubt as a qualification for a stocking knitting business he later established there [51] and Joseph Bastons, who was selling cotton in Barcelona to its Royal Spinning Company in association with his father in 1784, took up permanent residence in the city following his father's death in 1791 [52].

Torroella's move thus was representative of this growing interaction between capital and a dynamic component part of Catalonia's urban system. As was Anglada's case it was the introduction of stocking-frame knitting to the capital which appears to have been the primary grounds for his presence in the capital — certainly he operated stocking frames in the city [53] — but, like Bastons, he would have been acting too in the cotton market on the behalf of his family's cotton business. We find him in the course of the 1790s buying raw cotton in Barcelona on the behalf of other Oloti merchants, notably Joan Molleras. At the turn of the century he served as a financial intermediary for Mulleras too [54].

Turning then to the background for Torroella's involvement in the invention with which we are concerned, we can see that his business interests were of a kind to make it likely that Serrano's arrival in Barcelona soliciting for backing to build Arkwright machines would have come quickly to his notice; that coming from a cotton producing centre which was at the cutting edge of technical advance in spinning would have meant that he would have been fully aware of the vast commercial potential for a machine of the type that Serrano was offering; that he would have possessed ready outlets for the production from such machines; that his town's success

[51] Arxiu Històric de la Ciutat de Barcelona, Junta de Comercio, vol. 23, ff. 13-14, recurso of Anglada, 21 Jan. 1788.

[52] They were providing the Royal Spinning Company with cotton: BC, FG-J, Libro 11, Libro de Almazen de la Compª de Hilanza de Algodón de las Fábricas de Barcelona, 17 November 1784; for the move to Barcelona: Puig Reixach (1988b), p. 116.

[53] His transport of these backwards and forwards to Olot, and operation of them within the Serra/Torroella manufacture, was to be a cause of dispute between the associates.

[54] Thus the accounts of the Serra/Torroella concern for 1795-6 record his purchasing cotton for a range of Oloti, principally Molleras. For the financial services see Puig Reixach (1996), p. 441.

in the introduction and use of the earlier invention of the stocking frame, and his own close, family links with the leading constructor of this machine, would have provided him with the necessary confidence and practical experience to undertake the risky endeavour of introducing and developing a complex new technology.

2. Serra

Juan Serra, as he maintained, did indeed devote himself primarily to «su arte de Platero». He was one of the leading members of his profession. Among his customers were Catalonia's Intendant, Blas de Aranza, the marquis of Palmerola, president of the Junta de Defensa of Barcelona during the French war of 1793-5, leading merchants and industrialists, such as Joseph Gironella, Erasme de Gónima and the Bonaventura Gassó to whom reference has already been made and distinguished members of the city's French colony – the commercial company, Huguet, Vilella y Dupre and Juan de Larrard, the only foreign «comerciante matriculado» in the city [55]. He was involved too in the jewelry wholesale trade sending esmeralds and sapphires to the fair of Beaucaire, to Cádiz and to Havana (where his brother, Pau, had been trading since at least 1778) and diamonds to Madrid [56].

However, as was usual for rich guildsmen in Barcelona, Serra participated in trades other than his own [57]. Between 1789-90 he shipped lace together with jewelry from the small ports of Arenys and Mataró to Barcelona's north-east; between 1792 and 1793 he exported stockings to Vera Cruz, in 1793 eau de vie in return for sugar to America and in 1799 bullion to the fair of Beaucaire [58]. These eclectic investment habits drew Serra into the cotton importing trade in American in the late 1780s and, like the Bastons family, he was a supplier of the Royal Spinning Company of Barcelona between 1787 to 1790 [59]. Perhaps it was in this context that he came to know Manuel Torroella.

[55] Zylberberg (1993), p. 110.

[56] AHCB, FC, Juan Serra, B 307, as above, and B 306, Llibre particular de Juan Serra que conté tots los deutes de sos Acreedors lo que se les ha pagat desde Maig 1808.

[57] On the regularity of this practice *see* Molas Ribalta (1970), pp. 201-205.

[58] These details of Serra's activities are all drawn from AHCB, B 306 & 307.

[59] BC, Fons Gònima-Janer, L 11, Libro de Almazen, sales of 30 Nov. 1787, 30 May, 24 Nov., 6 Dec. 1788, & Feb. 1790.

A further sphere in which Serra distinguished himself was voluntary participation in the «public» realm. During the 1793-5 war he was made «Capitan de la Compañia Urbana», in 1796 he was appointed secretary of a Junta de Socorro set up to provide for unemployed workers, in 1802 he worked on a «Comisión de Obsequios» encharged with preparations for a visit to Barcelona by Carlos IV [60] and in 1805 he was elected by the city's guilds to serve as «vocal artista» to the Junta de Comercio [61]. In this last position, in which served until his death in 1816, Serra was assigned to sub-committees linked to technological change – one, in 1806, which was set up to evaluate Santponts's introduction of steam power in Jacinto Ramón's manufacture another, in 1814, to re-instate a «Cabinete de Maquinas» which had fallen into disuse because of the French wars [62].

In the course of practising this wide range of activities it seems likely that Serra, contrary to his claims, would have been given occasion to have had thoughts about «máquinas e hilados». The most likely context for such would have been the supplying of cotton to the Royal Spinning Company for he performed this service when the Company was involved in well-publicized experimentation with the spinning jenny [63]. Further possible ones, however, would include his committee work and even the selling of his wares in his shop, both activities which brought him into contact with the city's leading merchants and industrialists – Bonaventura Gassó, well informed about the Arkwright machinery we have seen, could have been a confidant. If it was the latter then it would be one of several, near parallels between the Catalan and English experiences of this invention: Arkwright, a barber by trade, was another non-professional enthusiast for invention whose curiosity concerning roller-spinning was incited while shaving his cotton weaving customers [64].

3. Serrano

Evidence concerning Pablo Serrano is more difficult to obtain. No proof has been located concerning his having served at the Royal Manufacture of Ávila, however this concern was the only possible source for his skills

[60] Molas Ribalta (1968), vol. IV.
[61] BC, JC, leg. 59, caixa 96.
[62] BC, JC, leg. 104, caixa 104, no 4, ff. 3, 12-13.
[63] See Sánchez (2000a), pp. 162-163.
[64] Fitton (1989), pp. 1-27.

in central Spain and, as noted, the type of spinning machine which he introduced, and the sets of machinery with which it was incorporated, were identical to those developed by the Milnes for Ávila. In the initial stages of the establishment of Ávila machine-building was carried out in a workshop in Madrid. It is possible, thus, that he had worked there. There is no evidence, though, for the continued existence of this workshop into the 1790s when Ávila was fully functional. If the deduction that Serrano's skills did originate in Ávila is correct then the further possibility exists that he was related to Rafael Serrano who was making his mark in the town as a woollen clothier in the period of the Royal Manufacture's development [65].

As a machine-maker Serrano was a key-worker. The salary which he was given in Barcelona attests to this. It was calculated on a weekly, rather than on a daily basis — the treatment accorded to higher status employees and it was high — 24 pesetas a week or some 475 libras per annum, which was above what was paid to most salaried directors of calico-printing companies. He was also granted a share of profits.

TABLE 1

Total number of, and annual additions to, the cotton spinning equipment of the Royal Manufacture of Ávila, 1791-1801 [i]

1791	*1792*	*1793*	*1794*	*1795*	*1796*	*1801*
66	84	113	117	126	135	139
37	34	29	4	9	9	4 since '97

[i] Martín García (1989), pp. 344, 348-349. For 1792 I have added 16 units which the manufacture was obliged to construct for Tarragona and the Royal Manufacture of San Ildefonso.

Why would he have left Ávila? Was it because of a collapse in the demand for machine-makers there? This hypothesis can be tested from the fairly complete records which exist for the royal manufature's machine-making. The table below summarizes this information in the form of a list of the number of units of spinning machinery accumulated by at a range of dates (the first line) and the number of additional units constructed annually (the second). The amount of machine-making going on in 1793, the year

[65] Martín García (1989), pp. 187-195.

Serrano arrived in Barcelona, was still high it can be seen. This is not to say, however, that the gains to be made at Ávila were were such to deter the ambitious machine-maker from leaving. A request was in fact received by Charles Milne to allow another machine-maker to leave the Royal Manufacture in the course of 1792. It was turned down on the grounds that «no convendria que ni éste ni demás oficiales de esta fabrica que han empezado a instruirse se les permita pasar a otras sin más motivo que su voluntariedad [...] bien sea porque se ven con alguna instrucción o porque piensan ganar con que aqui han aprendido». «Se cree» it was noted, that the «suplicante [...] haya inducido a otros compañeros a hacer lo mismo» [66]. Serrano could have been among these.

What can be said with some certainty is that by 1793, after five years of machine-building at Ávila, a substantial number of workers with machine-making skills would have been trained whereas demand for their services, in a sector with a single manufacture, was bound to be limited. Mediumto longer-term employment prospects could not have appeared good. It can be added that within this manufacture there was already a context for movement of labour *from* Barcelona — all the skilled workers for calico-printing had been secured there — and that it was common knowledge that the prospects for employment for cotton manufacturing by movement in the reverse direction were good — it was in Barcelona indeed that John Berry, co-founder with Thomas Milne of Ávila, had originally favoured the establishment of his manufacture on the grounds of the advantages which would have accrued from its well established cotton industry [67].

Looking at the issue in a broader context than that of labour-exchange between Ávila and Barcelona it can also be noted that by the conclusion of the eighteenth century the co-existence of an extensive network of royal manufactures and widespread, privately operated textile concerns was leading to an unusual degree of labour mobility nationally. The Royal Cloth Manufacture of Guadalajara, in particular, was an important source for skilled labour, tools and machinery. As González Enciso notes in its respect «La preocupación que antes había existido para la conquista del técnico extranjero se va a convertir, en los años ochenta y noventa, en la conquista del técnico de Guadalajara» [68].

[66] *Ibid.*, p. 295.
[67] *Ibid.*, p. 218.
[68] González Enciso (1976), pp. 588-590.

EXPERIMENTATION AND COMPLETION OF A PROTO-TYPE

The costs incurred by the Serra/Torroella company in constructing the first four Arkwright spinning machines necessary to make up a «set» of machinery was 3279 libras. The principal items included in this sum would have been the raw materials necessary for the machines, any wages paid to carpenters, turners and lock-smiths for labour and machine parts for them and the keep of, and payments made to, Pablo Serrano between August 17th 1793, when he started work on them, and 19th December 1793 when he signed his contract with the company. Not included, it would seem, was that part of the salary which Serrano received after December 19th until the machines were completed on March 24th 1794 which was attributable to machine-making. What was held by one of the associates to be the excessive amount of these costs became one of the grounds for the litigation concerning the company following its dissolution dragging on for so long. The consequent cross-examinations however had the fortunate consequence for us of generating interesting data concerning this critical stage during which Serrano's technological skills were exploited to construct a proto-type Arkwright machine.

It emerges that the high costs were a reflection of the extreme complexity of the machine. Examples of it started upon had to be discarded («muchas de las maquinas que hizo [Serrano] no pudieron servir»); others which were built had to be disassembled and rebuilt («desacerse, y montarse de nuevo»). Further costs were occasioned by a decision to make four different types of the machine («quatro primeras Maquinas de quatro distintas qualidades») and the thorough testing of each («Las muchas pruebas que debieron ô quiso [Serrano] hacer») [69]. Great care was taken it is clear to develop a well-tested proto-type of a machine which was going to be reproduced in significant numbers for the use of the partners' own enterprise and also, eventually, it may have been contemplated, sale to other spinners (clause 9 in the founding statutes of the Serra/Torroella company caters for such an eventuality).

In actual fact the costs incurred do not appear so high when they are set against prices paid for Arkwright machines a few years later [70]. They

[69] ACA, RA, RCC, pl. 7450, ff. 157-162 & 172-185, evidence of 2 Sept. & 27 Oct. 1803 & 2nd numeration, f. 60, 29 March 1803. At Ávila, too, more than one type of machine was in use, one with two cylinders for strong, warp thread and one with three for finer yarn [Martín García (1989), p. 343].

[70] 833 libras each was the valuation attributed to 18 machines installed in Martorell in 1807 or 3332 libras, slightly more, for four [Grau & López (1974), p. 41, n. 29].

were perceived as such, however, and conflicting reasons for this having been the case were given by the former associates. For Serra they were the result of Serrano's incompetence («por la poca pericia de Pablo Serrano Maquinista de la sociedad [...] gastó mucho mas de lo que en otra forma habria sido necesario, y de lo que habrian costado las maquinas y utencilios, si se hubiesen construido por Sugeto inteligente y versado», he was to claim). Torroella, on the other hand, stuck up for Serrano. Serrano, he claimed was (by 1802-3, when this evidence was being heard) «reconocido publicamente por demaciado Hombre de bien y habilidad» for Serra's criticisms to be credible: «si dixo que sabia la construcción de maquinas inglesas lo acreditó con la obra». Serra was to blame: «era el que con su genio transportado le atolondraba [...] haziendole deshazer lo hecho [...]. Revestido Serra de un aire de Despotismo sobre nostros, ordenaba como a Gefe absoluto mandando el Maquinista, ô mas propiamente perturbandole con ideas obscuras, y del todo ignorantes».

As the trial had progressed the depth of the analysis of Serrano's machine-making activities had increased leading, finally, to a more detailed breakdown of the costs incurred being presented. Included in them were substantial payments for files — a crucial, machine-makers tool — and for replacement cards for the carding machine — on which cotton would have been prepared for experimental spinning — as well as the costs for transporting the machinery to Olot and for «regalos al tiempo de concluirse las quatro primeras maquinas»: at this stage, at least, the achievement of Serrano and his collaborators must have been unquestioned [71].

THE MOVE TO OLOT

This took place as soon as a first working model was completed, the further proto-types being despatched on completion. In fact the move had already occurred, at a cost of 283 libras to the Company, when Serra, Torroella and Serrano formed their company and spinning started in Olot on 15th December 1793 [72]. For the Torroella family the initiative represented a major increase in the scale of their affairs. Some of the dimensions of the changes are shown by the records for Olot's cadaster payments:

[71] ACA, RA, RCC, pl. 4950, ff. 157-162, 164-167, 172-185, 195 evidence of 2, 30 Sept., 29 Oct. & 22 Nov. 1803 & 3rd enumeration, f. 18, evidence of 7 May 1803.

[72] AHPB, Ubach, 16 Aug. 1802, ff. 136V, 132V, 145R.

in 1790 they had been subscribed for the employment of two journeymen but in 1793 for eight [73]. The increased scale of their affairs enforced a search for more space – on January 4th 1794 the family rented the house adjoining their own in the Carrer de St. Antoni for a period of 3 ½ years. This rental it is likely was directly linked with the arrival of equipment from Barcelona. Terms of the contract which was signed which restricted the setting up stocking looms in the attic or galleried, top-floor area of the building suggest that it was here that the stocking frames which Torroella had transferred from Barcelona were set up [74].

The pre-spinning and spinning machinery by contrast was set up outside the town. One of the reasons for its transfer to Olot was, it is evident, the possibility there of harnessing it to hydraulic power and for this purpose the associates had rented a mill equipped with four fulling hammers situated on the river Fluvià facing the flour mill of Jubinyà de Parra in Sant Joan de las Fonts, a village some three kilometers to Olot's north. The best hydraulic resources of the Garrotxa were to be found there. The mill belonged to Antonio de Trinxeria and its tenants, a French company, Lajad Brun, had been using it for tanning. They sublet it to Serra and Torroella for four years for an annual rent of 200 libras [75]. Reference in the later court proceedings to the «casa y molino que servió para el curso de la Fábrica» removes any doubt that here the spinning machinery was adapted for driving by water power. This was a futher «first» in Catalonia for the Serra/Torroella association [76].

Additional evidence concerning the experiences of the company in Olot is limited. The 1794 cadaster records are missing and there is no record to be found for the Torroellas' spinning initiatives in the town's notarial registers for this year. Was secrecy being maintained about the enterprise to restrict diffusion of the new technology? It is highly likely. As late as 1796 leading spinners using the improved spinning jennies do not appear to have been aware still that the Arkwright technology was even in use in Catalonia [77]. We know that Torroella and Serrano were responsible for

[73] AHCO, Cadaster. ACA, RA, RCC, pl. 4950, 3rd enumeration, f. 27, Serra complains that the Company had born the transport thus for transport costs particular to Torroella.

[74] AHCO, Notarial archive, Casabona Caralt, Manual, 4 Jan. 1794, ff. 2-4.

[75] ACA, RA, Registros, no 1119, ff. 261-262: information proceeding from court case between Trinxeria, Serra and the Torroella. I am grateful to Ramón J Pujades for guiding me to this information. On the flour mill see Caula (1981), pp. 168-169.

[76] Certainly the first case of water-powered Arkwright machinery in Catalonia, though not in Spain, although there is a claim for water-powered spinning, presumably with a jenny, in the neighbouring town to Olot of Bañolas in 1793 [Sánchez (2000a), p. 171].

[77] This is apparent from a report of the introducers of the Highs improved jenny to Catalonia of September 1796 cited in Thomson (1992), p. 256.

all the practical details of setting up the manufacture in Olot. Torroella clearly had to divide his days between his family business and stocking-making in Olot and the spinning taking place in Sant Joan las Fonts: a horse which he purchased in the course of the year, and whose cost he charged to the Company, would have served for getting to and fro [78]. Serrano's machine-making, -installing and -operating duties would have required his dividing his time between Barcelona and Olot. It was in Barcelona that he worked until March 1794 to complete the full set of four Arkwright machines [79]. In Olot he not only installed the machinery as it arrived from Barcelona, and exercised his responsibility to ensure its correct functioning, but also must have supervised extensive machine making which was commissioned within the town. 7530 libras 11 sueldos 10 dineros were spent by Torroella on «Maquinas y utencilios» during the year which the manufacture operated in Olot, far more than the 2412 libras 10 sueldos 2 dineros which was the total for all other expenses other than wages. The Serra/Torroella association was principally a machine-making one at this stage it is clear. The total expended on spinning in the course of the year was 3635 libras. Olot's plentiful machine-making resources were being made full use of. A substantial part of the other expenses would be accountable for by the adapting of the Sant Joan las Fonts mill for the powering of Arkwright machinery – in itself a complex operation, even though only a single set of machinery was being powered initially. An issue in a later legal dispute between de Trinxeria and the company was the latter's refusal to return timber and other equipment which had been introduced into his mill by the associates, it is to be presumed for this purpose [80].

Serra remained in Barcelona and exercised there his responsibility for purchasing raw cotton for the Company. 6878 lbs were bought of which 4357 lbs were spun into yarn in Olot, the bulk, 3638 lbs, for local sale. The price which it fetched, 33 sueldos 6 dineros the lb (10-15 sueldos more than that for handspun yarn) marks it as having been yarn of medium to fine quality, of the type marketed as «machine yarn» in local yarn markets. The yarn needs of the local, Garrotxi cotton stocking frame knitters and muslin weavers were clearly being catered for [81]. The existence of such

[78] AHPB, Ubach, 16 Aug. 1802, f. 144V.

[79] Thus in the accounts the costing for these machines and of their transport to Olot is separate and recorded as taking place between August 19th 1793 and 24th March 1794 (AHPB, Ubach, 16 Aug. 1802, f. 136V).

[80] Also Trinxeria was claiming for rental payment despite the need to abandon the mill during the French war (ACA, RA, RCC, pl. 7450, 3rd numeration, f. 32).

[81] AHPB, Ubach, 16 Aug. 1802, ff. 132V, 142R.

a local market was yet another advantage accruing from the Olot location just as it had been for the deployment of the first Arkwright machines in Nottingham in England [82].

As we have seen from contract by which the Serra/Torroella company came into existence, the original intention was that it should operate «por ahora» in Olot. The further contract with de Trinxeria for the renting of his mill shows that a period of at least four years was intended by this. On December 7th 1795, however, spinning in Olot was brought to a halt and the company's machinery was disassembled and transported back to Barcelona. A near doubling in the transport charge for this return journey attests to the amount of machine-making that had taken place in Olot. Serrano was back in Barcelona from December 20th to supervise the machinery's installation [83].

Why the return? The answer is to be found among the evidence presented at the court case. The mill at Sant Joan de las Fonts, it is recorded, «no pudo servir en parte del tiempos que duró la guerra con Francia» [84]. The fortunes in the conflict, which had flowed in Spain's favour initially, had turned in the course of 1794 following a defeat at the battle of the Ampurdan in November, Olot consequently finding itself near the front line. Military engagements took place on the road leading to it from Camprodón, which had fallen to the French, in May 1794, and, in February/March 1795 at Llorona, in the Alt Empordà, to its north. The Fluvià itself became a line of defence [85]. As sacking and torching were the fate of areas occupied by the French the continued operation of the manufacture was clearly too great a risk to take.

Back in Barcelona:

(a) *Installation of the machinery and machine-building inside and outside the manufacture*

To house the manufacture what had been a calico-printing manufacture, situated in front of the chapel of Sant Llàtzer, probably that of Armengol Gener whose premises had been vacated following bankruptcy in 1794 [86],

[82] Chapman (1966), pp. 87-88.
[83] *Ibid.*, ff. 145R, 136V, 145R.
[84] ACA, RC, pleito 7450, 3rd enumerations, f. 32.
[85] Jordà Güell (1975), pp. 41-50.
[86] Delgado Ribas (1982), p. 124. The accounts show Serra and Torroella buying equipment from Gener's creditors suggesting this.

was located for an annual rent of 1200 libras [87]. This was in the Raval area of Barcelona, south of the Ramblas, in which most of the city's industrial expansion since 1783 had been concentrated. The manufacture belonging to Erasme de Gònima, the most notable figure in the city's calico printing industry at this stage, was in the adjoining square [88].

It took some four months for the installation of the machinery to be completed, spinning being recommenced in April 1795. The length of this time would appear to be accountable by the need, in the fulfilling of which Pablo Serrano would again have been the principal agent, not only to reconstruct and instal the machinery returned from Olot, but also to resolve a requirement which arose from the manufacture's now urban situation, far from any sources of hydraulic power — the devising of an animal-driven system for the provision of power within it. The inventory which was drawn up in the context of the manufacture's division between Serra and Torroella lists the equipment used for this purpose and, although it relates to a period when more machines had been built, and the production line would thus have been more extensive, the principles of the system created would not have changed. Power was provided by a total of six mules harnessed with collars in pairs to capstan bars which rotated three bronze plated, wooden columns. These delivered rotary energy to horizontally slung, again bronze-clad, shafts built into a wooden structure which stretched the length and breadth of the manufacture's working area. From these rotating shafts power was delivered to the individual machines by a system of wheels and drive belts, which included in 1799 37 «ruedas medianas del cabo de las maquinas» and 11 «ruedas grandes de las correas de cardar». What had been created is familiar to us from any view of the interiors of cotton mills before the use of the electrical motor: a geometrical complex of columns, drive shafts, gearing mechanisms, wheels and drive belts linking every machine to a single power source. It was, of course, a more costly and less efficient form of energy provision that had had to be devised than the hydraulic power which had been used in Olot. Some of the differentials can be crudely expressed. The mules alone cost 1251 libras, well over the four years rent of the Sant Joan las Fonts mill, and the cost for their fodder was 1251 libras in 1795 and no less than 3613 libras, a year of food shortage, in 1797 [89].

[87] Location revealed in court case (ACA, RC, pleito 7450, f. 21).

[88] See Thomson (1992), pp. 227-232.

[89] AHPB, Ubach, 16 Aug. 1802, ff. 129-131, 137V, 138V. On food prices in the 1790s Vilar (1962), II, pp. 384-418.

TABLE 2

Expenditure on machinery by Serra, Torroella enterprise, 1795-1798 [ii]

	1795-1796 (Serra)	*1795-1796 (Torroella)*	*1797 (Serra)*	*1798 (Serra)*	*1798 (Torroella)*
Machine-making					
Cerrajeros	2.427	2.516	1.590	474	869
Cerrajeros with carpinteros		4.944			
Torneros	365	1.111	351	96	338
Carpinteros	2.322		758	257	
Latoneros	863	1.469	1.118	399	
Sillero	75				
Vidriero	870				
Colletero	67				
Tools bought					
Various	327				
Files		229		50	
Raw mats.					
Plomo	1.356				
Parts					
Rodetes	507			239	
Cards	396		2.498	961	
Traction					
Mules		1.128			
Unattributable				2.517	
Totals	9.575	11.397	6.315	4.993	1.207

[ii] *Ibid.*, ff. 136V, 137V.

In Barcelona machine-building continued. It was to be at its most intense between 1795 and 1796, expenditure on it running, as can be seen from the table below (which excludes Serrano's wages), at some 10000 libras a year, a similar rate to that registered in Olot during 1794. It then declined sharply from 1797. From this point the Serra/Torroella manufacture *was* primarily a cotton-spinning one. Bulking large in the costs for 1797 and 1798 was that for replacement cards for the carding engines

–a recurring cost related to the use of the machinery. «En los tres primeros años se gastó mucho mas que en los otros dos», Juan Serra was to state at the later court proceedings with respect to the concentration on fixed capital investment between 1793 and 1796.

As table 3 below shows most of the work generated by this intense machine-making continued, as in Olot, to be carried out by a range of independent artisans contracted by the manufacture. They are not though described as «machine-makers» . They would have been would have been working to the orders of Serrano who certainly in the case of the key, spinning machines would have actually put the machines together with the assistance of a group of carpinteros, torneros and cerrajeros employed by the Company, described as being «de casa». Even when new machine-building ceased from 1797 this core of in-house workers was retained. We can see this from the wages which continued to be paid to them. They would have been needed for the maintenance and servicing of machinery.

TABLE 3

Machine making inside and outside the Serra/Torroella manufacture

	1795-1796	*1797*	*1798*
Fuera de casa	15.155	1.877	1.226
En casa	1.869	1.941	1.207
Replacement tools and expendable machine parts	1.132	2.498	1.250

A further continued machine-related cost was the regular need to replace cards for the carding engines and wooden bobbins, the former in particular wore out quickly and represented an important element in production costs. Juan Serra, the variety of whose testimony in the court case goes a long way to confirming what Torroella referred to as his «genio», was to comment that «estas [the machines generally] se consumen ê inutilisan muy facilmente, haviendose de hacer de nuevo muy a menudo y casi continuamente, consistiendo en limas, cardas y otros que en si lleva el curso de las indicadas Máquinas y fabricas de la naturalesa de la que tratamos» [90].

[90] ACA, RCC, pleito 7450, 2nd set of numeration, ff. 172-185.

The thoroughness of the inventory executed in the manufacture in 1799 provides further insights into these machine-making and maintaining rôles which bulked so large in the existence of the first, Catalan, Arkwright mill. Listed in it are the machine tools and equipment used, including four machines for planing wood, various carpenters', locksmiths' and turners' tools, iron vices, a gimlet, a grindstone, an iron bench and other equipment for servicing a furnace, the furnace itself and brass moulds «para vaciar maquinas nuevas». The various planing machines are accounted for by wood's providing, it is evident, by far the principal construction material for the machines and their driving mechanisms. Of particular interest is the existence of the small foundry for casting metal parts of the machinery. The principal of these would have been the cylinders for the carding engines, drawing frame and roving frames and spinning machines. Such casting work could, clearly, have been sub-contracted in the way that the provision of other of the machines' components were – lock-smiths would have been the source for it. It would appear that its execution within the manufacture is accountable for by the desire to retain secrecy about these critical parts of the machinery. The moulds themselves were the only items which were not later split between the associates. There must have been a single set of them and this, it was stipulated, was to remain available to both «para la fundición ulterior que necesiten».

Raw materials stocked in the manufacture included 690 lbs of bronze, 1.214 lbs of lead (for weights used for the spinning machinery) as well as quantities of tin, which was used extensively for reinforcing wooden textile machinery as well as for the making of the tin cans into which the «sliver» of carded cotton was coiled after it had been elongated and narrowed in the drawing frame (also known as the «can frame» or «lantern frame») and before being further attenuated, and having some twist put into it, by the roving (or «fly») frame prior to spinning.

(b) *Production of the Serra/Torroella manufacture in war and peace, 1795-1798*

The records are summarized in table 4. They represent a precious source for interpreting the complex series of changes in Catalonia's cotton industry during the transition from the long period of expansion which had been taking place since 1783 to these critical, war-disturbed years. Firstly they show a major shift in the priorities of the concern. On its return to Barcelona

it ceased to sell yarn but rather wove what it produced into cloth for disposal on Barcelona markets. This practice it continued through to 1797 when it began, again, to market small amounts of yarn which it was producing. For this weaving the associates purchased seventeen looms. It began on May 15th, 1795, as soon presumably, as sufficient yarn had been spun for it to take place.

It is possible that one reason for this vertical integration was in the interest of continued maintenance of secrecy about the Arkwright machinery — it was by selling yarn on the open market that the existence of Samuel Crompton's invention was betrayed. An alternative, or additional reason, for it, was the fact of the manufacture's return to Barcelona coincided with major changes in the international trading situation for linen and cotton cloth. The European war which had begun in 1793 had led to a gradual breakdown in the international supply networks for these causing the Catalan market for them to dry up. In their default, a great increase

TABLE 4

Production details for Serra/Torroella concern 1793-1798 [iii]

	1793	*1794*	*1795-1796*	*1797*	*1798*
Raw cotton bought....	787 lbs	6.091 lbs	31.838	20.878 lbs	15.455 lbs
Yarn produced.....		3.638 lbs spun in Olot, 719 lbs spun in Barcelona		1.330 lbs	9.242 lbs
Yarn, proceeds (libras, sueldos, dineros)		6.111-18-6 and 929-14		2.659-2-10	23.472
Yarn: price attained per lb in sueldos....		34 and 26		40	51
Cloth: number of pieces woven			2.868	2.434	1.641
Proceeds of cloth sales.			58.416-7-1	48.206-12-7	28.727-10
Average price attained for pieces of cloth ..			20-7	19-16	17-10
Spun yarn bought on open market			4.049 lbs		

[iii] AHPB, Ubach, 16 Aug. 1802, ff. 142R.

in demand had been experienced for locally produced cotton cloth for printing, referred to as «empesas» because of the gum mixture which provided its finish. Such was the demand for, and profits to be obtained from, this type of cloth that, as can be seen from the table, Serra and Torroella in contributing to satisfying it actually purchased considerable, additional quantities of imported yarn to that which they were producing themselves between 1795 and 1796. Production of «empesas» for calico printing had become the great trade of the moment, drawing on the large capitals which had been immobilized by the collapse in the international trade in «lienzos». This, to go back to Sánchez's argument in our introduction, was the enforced «return to cotton», but it beginnings we can see, took place some three years before the outbreak of war with England, though initially with less dramatic consequences for Catalan spinning than weaving in view of the continued elasticity shown in the supplies of Maltese yarn through to 1797 [91]. Continuing the analysis of the table, the impact of the war with England on the manufacture is also detectable. The difficulties in importing yarn, and resultant high profits attainable from spinning, would account for the increasing resort by Serra and Torroella to selling part of their manufacture's yarn in the Barcelona market from 1797. By 1798 the proceeds from yarn sales were nearly the equal to that from cloth it can be seen.

The gradual abandonment of the weaving of empesas would be accountable for in terms of a decline in the demand for them in view of the war's curtailment of American exports. The domestic market was not affected so much and with respect to this the range of higher quality cloths sold was greater. Here the manufacture stood to gain by the capacity which its machines provided for producing higher quality yarns. The movement towards a high quality yarn specialization is detectable from the increased price attained by the manufacture for its yarn sales between 1797 and 1798: it was returning at this point to the production of the type of yarn for the provision of which it had been originally set up.

CONCLUSION

The Serra/Torroella association ceased at the end of the five year term for which it had initially been set up, in December 1798. It was Manuel

[91] A similar, huge transfer of capital from the international trade in toiles to cotton manufacturing in France is recorded by Bergeron (1975).

Torroella who had expressed the wish to disassociate. The grounds were his desire to found his own manufacture. For this purpose in the course of 1798 he had contracted to rent a building in course of construction close to the existing manufacture for the annual rent of 1100 libras [92]. As required by the company's statutes, he had informed Serra of his intentions six months before the company's expiry, in June 1798. Curiously, from that point he played no more part in the running of the concern whose foundation had been his initiative, whose manufacturing and machine-making side he had managed from the outset (residing within it when it had been situated in Barcelona) and in which he still held a fifty per cent stake. «Desde el 23 junio ultimo», it was noted at the inception of the court proceedings with Serra in early 1799, «no ha cuidado ni intervenido en el manejo de la fábrica, ni en cosa alguna que tuviese relación a ella, demostrándose ya estar enteramente separado de ella» [93]. The rather ambiguous arrangements for a partner's leaving the enterprise had clearly been followed to the letter.

Initially the disassociating does not appear to have given rise to friction. On October 19th the partners named «arbitrarios y compromisarios» to represent them in the division. These started to work on their behalf from October 26th, holding a three hour «junta» with Serra and Torroella on November 19th 1798 to «acordar el modo de partir los utencilios de la fab_{ca}». Following this, on November 24th, the imminent termination of the company was registered before a notary. From this point, however, negotiations broke down. Torroella's account of the events was that while he had «apurado todos los medios para terminar el asunto amytosamente *[sic]*», Serra's arbitrator had absented himself from a critical meeting to initiate the division in an attempt to obstruct the process thereby prolonging Serra's control over the concern [94].

The court case was precipitated by an action of Torroella. Hard-pressed financially in view of the costs he was incurring for the establishment of his own manufacture, and becoming pessimistic about Serra's preparedness to pass on the share of the company's machinery and capital to which he was entitled, he anticipated on some of what he was due by taking payment for two of the manufacture's recent yarn sales. Serra's response

[92] AHPB, Ubach, manual for 1798, ff. 470, 476-479, acts of 26 November 1798.

[93] ACA, RCA, pleito 7450, ff. 7-8.

[94] AHPB, Ubach, 16 Aug. 1802, f. 129R; ACA, RCC, pleito 7450, ff. 9-11 (T's statement), 9-11 (notarial contract bringing company to end), 59-61, details of time spent by the arbitrators on the division.

was to sue him, claiming that he, «como â Prâl encargado de la Fabrica no solam$_{te}$ tiene contrahidas todas las obligaciones correspondientes â ella, sinó tambien porque siempre se ha entregado â el [...] todas las partidas resultadas de la expresada Fabrica». The court proceedings caused the division of the machinery to be delayed until March 1799. The perusal of the accounts of the manufacture was then to be a preliminary for a final liquidation but delays in producing these — they only became available in 1802 — and then their complexity, and repeated litigation in their respect, instigated principally by Serra who showed himself a master of legal process, delayed a final reckoning until July 1805. It seems clear that Serra, who was benefiting from the status quo — possession of the original manufacture and the holding of its balances — profited from the original ambiguity concerning the procedures for dissolving the association to do all he could to delay it. This was certainly the belief of Torroella, repeated on many occasions during the dispute: «Toda su idea», he claimed for example in January 1799, «consiste en apropiarse de los caudales de la fábrica en los cuales tengo iguales intereses con la mira de perjudicarme e imposibilitarme para poder emprender mis negocios para evitar se llegue a la liquidación y división de la fábrica» [95].

This article's concern is not however with the quarrel between Serra and Torroella and its consequences important though these were to prove for the diffusion of new technology in the Catalan industry – a second Arkwright spinning manufacture had been spawned, Torroella's, in the form of what was the first, customized, mechanical spinning building in Barcelona, one which was later rented to the Conde de Cabarrús to house the first spinning mules used in the city [96] and Serrano, who can have had little to do since the Serra/Torroella manufacture ceased expanding at the end of 1796, moved to Manresa at some stage between 1799 and 1801 and there, no longer contractually bound to working for Serra and Torroella, he was to equip a new spinning industry by means of a manufacture which he founded himself in 1801 and by his participation as a machine-building associate in the Dalmau/Codina company which was operating two manufactures (he had built no less than 37 further Arkwright machines for them by 1806) [97] – but rather with the five year duration of the original

[95] ACA, RCC, pleito 7450, ff. 4-6, 18-20 (for two quotations).

[96] AHPB, Ubach, 9 March 1802, ceding of land to Torroella, 18 March 1804, ff. 336-337, receipts from craftsmen for nearly 23000 libras for cost of building this manufacture, Matheu i Smandia, 1806, ff. 53, for foundation of Cabarrús's concern and renting of Torroella's building; Benaul Berenguer (1992), for the transfer to Sabadell.

[97] ACA, RCC, pleito 7450, f. 136; Ferrer Alòs (1999), p. 1051; Sánchez (1988), p. 98.

company during this critical stage in the industry's mechanization. What light has our narrative thrown on this?

Firstly, with respect to the issue of the introduction of machine technology to the Catalan industry, we have seen that there was a first, and important, phase to this which was the fruit of a steady progress in the cotton manufacturing sector, achieved behind a protective tariff, which had occasioned a growing demand for higher quality yarn of regular quality. This demand had first been met by imported yarn, largely from Switzerland, but increased skills with machine technology in Catalonia had then made possible its supply, for all but the highest qualities, locally. The introduction of the Arkwright machine in Olot can be seen as part of this process of import substitution as well as being, taking a broader look at the causal process, a consequence of that optimism which characterized Catalonia at the beginning of the 1790s as its economy, as Pierre Vilar has shown, attained a peak in the long growth process which it had been experiencing through the century. A preparedness to take risks and a preparedness to take them outside a usual area of economic specialization, and outside a usual circle of commercial collaborators, characterize the foundation of the Serra, Torroella, Serrano company.

We have seen, though, that the firm's experience suggests that the European warfare from after 1793 began to act as dampener to this progress in spinning for while it caused a first «return to cotton», it was not a return which benefited machine spinning in particular in view of the elasticity of the cotton supplies from Malta through to 1797 and the lower quality of the yarn which was put into «empesas», which could be supplied by hand spinning or via «maquinas sencillas». The changing composition of the firm's output — a return to a specialization in spinning — and changes in its quality — a return too to the production of higher quality yarn — in 1797 and 1798 serve then to confirm the importance which has been attributed to the year 1797 as a stimulus to Catalonia's machine spinning. With respect to machine-building, a first point which has not yet been emphasized is that the early adoption in Catalonia of Arkwright technology was a spin-off from the great power status of Spain in the period leading up to the French Revolution which enabled it to acquire an early stake in this as yet very little diffused technology. No other route than the governmentally created one for the passage of the Arkwright technology to Catalonia at this early stage has been detected though some

ten years later alternative, direct routes from France, principally via Toulouse, were developed [98].

In addition in the section of the article which I devoted to Pablo Serrano's earlier career, I have suggested that the underlying grounds for a diffusion of the technology from Ávila to Catalonia was an unexpressed tension inherent to the Spanish monarchy's policy of establishing royal manufactures which incorporated machine-building plants in view of the the manufactures' inability to absorb the production of which these soon became capable. The degree to which this tension came to feed even more intensely into Catalan industrialization as the state manufactures became implicated of the country's severe «crisis del antiguo régimen» is an issue which may repay further research. A further, key Ávila technician who transferred to Catalonia to play a rôle in the Principality successful process of import substitution during these critical years was the royal manufacture's cotton weaving director, Henry O'Brien, who offered his services to, and was employed by, Sunyer of Reus in 1803 [99]. With respect to machine-building within Catalonia, the Serra/Torroella manufacture's case has provided further evidence for a recent discovery of Catalan economic historians – the abundance, and wide diffusion of the Principality's machine-building skills. This accounts for the relative facility and economy with which the early technological changes in the cotton industry could be introduced. The existence of this capacity for innovation represents an important, additional explanation for the precocious success of Catalonia in the industry [100].

Technological diffusion in the case of complex machines, such as Arkwright's, could still be slowed down by secrecy. There do not appear to have been any reproductions of the Arkwright technology outside the Serra/Torroella manufacture before 1797. In that year, or possibly slightly earlier, Jacinto Ramón would seem to have begun using the machine [101]. The possibility of doing so may have been provided by the tailing off from that year of the Serra/Torroella's concern's machine-building, releasing

[98] Hemardinquer (1959), pp. 86-88.

[99] Arxiu Històric de Reus, Fons Sunyer i Cia, correspondence, letter of 1 December 1803.

[100] See especially Solà (1995), pp. 12-15, on this.

[101] A grounds for believing this is Ramón's assumption of the sole supplying of the Royal Spinning Company of Barcelona with substantial quantities of spun yarn (some 600 lbs a week) from August 1797 at a higher cost, 11 to 12 sueldos, than that which had been charged previously by the Company's manual spinners, 11 to 12 sueldos the lb against 7 ½ sueldos. This would suggest he was supplying higher quality machine-made, probably Arkwright, yarn (JC, BC, FG-J, 56/2).

machine-making resources of which Ramón took advantage. But this is not altogether clear. The scientist Santponts was to write as though Ramón's success took again the form of a quasi-invention- «A este sujeto verdaderamente digno de los mayores elogios», he claimed, «debe Cataluña haberse establecido varios ramos apreciables de industria, particularmente la introducción y perfección del método de hilar algodón con máquinas inglesas que descubrió a fuerza de mucha aplicación, gastos y desvelos» [102]. On the other hand his machines were as those of Serra and Torroella, with 48 spindles each – the Milne and Ávila hallmark [103]. The issue is not one concerning which the sources are very informative. The Serra/-Torroella concern restricted, we have noted, Serrano's right to work for others. One of several reasons for operating the machinery in Olot I have argued may have been to increase secrecy concerning it. The fact that Serra and Torroella made no attempt to gain official backing for their initiative may, too, have been related to a desire to keep their invention to themselves for any support provided would have had diffusing conditions attached to it. The complete lack of any contemporary comment concerning a concern which played so wide-ranging a pioneering rôle in the Catalan industry — with its firsts in the Arkwright technology, in the harnessing of both water and then animal power to powering spinning machinery and then, apparently, in the case of Torroella's successor manufacture, in that of factory design for spinning — suggests that very little can have been known about it. This too would be consistent with its owners having shown discretion about the technologies from which they were drawing profit. It would account for so important a manufacture being so little known about for so long.

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[102] Agustí (1983), p. 145.

[103] BC, FG-J, 45/10: lists Ramón's equipment in 1803 which includes 16 such machines.

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